MANAGED PRESSURE DRILLING IN MALAYSIA

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All praise and glory to Almighty Allah s.w.t
that make all this possible,
to my wonderful parents and siblings
for their encouragement and motivation,
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ABSTRACT

Operators in the oil and gas industry are constantly seeking cost effective methods of drilling and producing oil and gas wells to optimize production and maximize profits. Conventional drilling methods have been overwhelmed with huge operational and financial challenges, where a considerable amount of money is spent for drilling related problems; including stuck pipe, lost circulation, and excessive mud cost. Managed pressure drilling (MPD) is the new technology that enables a driller to control bottomhole pressure in the wellbore to prevent these drilling related problems. There are different variations of MPD method are designed for different problems. MPD is achieving remarkable successes in well construction applications that have been impossible using conventional methods. In less extreme applications, the technology greatly reduces risk and improves efficiency. In both cases, it helps extend the scope of deepwater prospects around the world. Most of the hydrocarbon reservoirs in Malaysia are located offshore with increasing interest in drilling deepwater well where MPD method can be benefits. As the industry remains relatively unaware of the full spectrum of MPD benefits, this dissertation will reveal in details the two MPD techniques; constant bottomhole pressure (CBHP) and pressurized mud cap drilling (PMCD) that frequently being used in Malaysia. Readers will walk through an overview and detailed applications of both methods cover determination of pore pressure and fracture gradient, wellbore breathing detection, bullheading scenario to overcome total losses and specific mud weight design for each case history.

ABSTRAK

Pengusaha-pengusaha industri minyak dan gas terus-menerus mencari kaedah penggerudian dan penghasilan minyak dan gas yang lebih kos efektif untuk mengoptimumkan pengeluaran dan memaksimumkan keuntungan. Teknik penggerudian lazim selama ini memberikan cabaran kewangan dimana jumlah yang besar perlu diperuntukan kepada masalah yang dihadapi sewaktu aktiviti penggerudian termasuklah paip tersekat, kehilangan edaran cecair dan kos perbelanjaan lumpur yang tinggi. Menguruskan tekanan penggerudian (MPD) merupakan teknologi baru yang membolehkan penggali mengawal tekanan telaga pada kedalaman lubang yang tertentu. Terdapat beberapa jenis teknik MPD yang direka untuk mengatasi pelbagai jenis masalah penggalian. Teknik ini telah mencapai kejayaan yang cemerlang dalam aplikasi pembinaan telaga di kawasan yang mustahil untuk digali menggunakan teknik lazim selain daripada mengurangkan risiko dan meningkatkan kecekapan. Ini membantu memperluaskan skop prospek laut dalam. Kebanyakan lapangan minyak di Malaysia terletak di kawasan laut dengan peningkatan minat yang ketara oleh pengusaha minyak untuk meneroka laut dalam di mana teknik MPD boleh diguna pakai. Disebabkan industri masih belum sepenuhnya mengenali teknik MPD, laporan ini akan mendedahkan secara terperinci dua teknik MPD; tekanan dasar lubang yang berterusan (CBHP) dan penggerudian lumpur bertekanan (PMCD) yang kerap digunakan di Malaysia. Pembaca akan mendapat gambaran keseluruhan dan aplikasi terperinci untuk kedua-dua teknik merangkumi penentuan tekananp pori dan kecerunan pecahan formasi, kenal pasti pernafasasn telaga, teknik mengatasi situasi lumpur hilang secara keseluruhan ke dalam takungan dan rekaan berat lumpur yang bersesuain untuk setiap kes sejarah.

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LIST OF ABBREVIATIONS

AFP	-	Annular Frictional Pressure
BBL	-	US Barrels
BP	-	Back Pressure
BHA	-	Bottomhole Assembly
BHP	-	Bottomhole Pressure
BOP	-	Blowout Preventer
CBHP	-	Constant Bottomhole Pressure
CIM	-	Candidate Identification Mechanism
CPD	-	Controlled Pressure Drilling
CSM	-	Candidate Selection Mechanism
CTD	-	Coiled Tubing Drilling
CWD	-	Casing While Drilling
DAPC	-	Dynamic Annular Pressure Control
DD	-	Directional Drilling
DFC	-	Dynamic Flow Checks
DFIT	-	Dynamic Formation Integrity Test
DGD	-	Dual Gradient Drilling
ECD	-	Equivalent Circulating Density
EMW	-	Equivalent Mud Weight
FP	-	Fracture Pressure
FG	-	Fracture Gradient
GPM	-	Gallon per Minute
HD	-	Horizontal Drilling
HPHT	-	High Pressure High Temperature
HSE	-	Health, Safety and Environment
IADC	-	International Association of Drilling Contractors
IUBO	-	International Underbalanced Operations

LAM	-	Light Annular Mud
LWD	-	Logging While Drilling
MDDF	-	Measured Depth Drilling Floor
MPD	-	Manage Pressure Drilling
MWD	-	Measurement While Drilling
MW	-	Mud Weight
NPT	-	Non-Productive Time
OBD	-	Overbalanced Drilling
PMCD	-	Pressurized Mud Cap Drilling
PP	-	Pore Pressure
PRV	-	Pressure Relief Valves
RCD	-	Rotating Control Device
RFC	-	Return Flow Control
ROP	-	Rate of Penetration
RSS	-	Rotary Steerable System
SBP	-	Surface Back Pressure
SFC	-	Static Flow Checks
SIDPP	-	Shut In Drill Pipe Pressure
TD	-	Total Depth
UBD	-	Underbalance Drilling
WBP	-	Wellbore Pressure

LIST OF SYMBOLS

P_{hyd}	-	Hydrostatic Pressure
P_{BH}	-	Bottomhole Pressure
$P_{supplemental}$	-	Supplemental Pressure
P_f	-	Formation Pressure
$P_{friction}$	-	Friction Pressure
P_{choke}	-	Choke Pressure

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

World energy demand is increasing continuously to meet the need of energy of the developing countries. Increase in the energy consumption rates forces the scientists and engineers to discover another ways of gathering energy or better ways to recover the sources that we have been already using for years. Most of the world's remaining prospects for hydrocarbon resources will be more challenging to drill than those enjoyed in the past. Some industry professionals would say that 70% of the current hydrocarbon offshore resources are economically undrillable using conventional drilling methods (Dave et. al, 2011).

Traditional drilling practices rely on maintaining hydrostatic pressure in the annulus to prevent formation fluids from entering the borehole. Ideally, when drilling fluid, or mud is circulated down the drill string and up the annulus, an equivalent circulating density (ECD) is created that is greater than pore pressure, but is below the pressure necessary to fracture the formation being drilled. This pressure is often referred to as the fracture gradient (FG). The pressure range above pore pressure and below fracture initiation pressure is the drilling margin, or pore-pressure-fracture-gradient window. If at any point the ECD goes outside these bounds, operators must set casing and begin drilling the next smaller hole size.

The practice of maintaining a borehole pressure that exceeds the pore pressure gradient is called overbalanced drilling (OBD). According to Dave et. al (2011), It has been the method of choice for the majority of wells drilled since the early 20^{th} century. But OBD has its drawbacks. Foremost among them is its dependence on the use of multiple casing strings to prevent fluid losses, as the fluid density required to contain formation pressure is increased and ECD approaches fracture initiation pressure.

In some instances, particularly in wells in ultradeep water, pore pressure maybe high relative to formation strength even in the shallower sections of the well, which forces the operator to set numerous casing strings before reaching the target formation. The result can be a well whose diameter at total depth (TD) may be too small to accommodate production tubing large enough to produce economic volumes of hydrocarbons. Additional string of casing usually raise the final cost of the well significantly above initial estimates.

Besides the considerations when drilling overbalanced, mud filtrate and mud solids can cause damage to the formation. When solids invade and are deposited in pore spaces, they may impair productivity and lower ultimate recovery. In addition high overbalance during drilling can cause differential sticking and other problems related to hole cleaning, Efforts to free stuck pipe routinely results in hours or even days of non-productive time (NPT). In the worst case, the drill string may become permanently stuck and may be lost or require side-track in the presence of other aggravating conditions (Syafiq, 2015).

Dave et. al (2011) added, as operators drilled horizontal sections to expose enough formation to make their wells profitable, they found it impossible to maintain ECD below the fracture gradient. That is because while the fracture gradient increases with total vertical depth, it remains virtually unchanged from the heel to the toe of horizontal wells. However, as the wellbore lengthens, friction pressure losses increase. Pump pressure must then be increased to maintain sufficient circulation rates to lift cuttings to the surface via the annulus. Given sufficient length along a horizontal section, the ECD will result in a bottomhole pressure (BHP) that equals and then exceeds the fracture initiation pressure, with inevitable unacceptable levels of fluid loss.

In wells or section of wells with very narrow drilling margins, operators have addressed the issue of fluid loss through underbalanced drilling (UBD), during which ECD is kept below the pore pressure of the formation being drilled. As a consequence, fluids from exposed formations are allowed to flow into the wellbore during drilling operations. This prevents drilling fluids from entering even under pressured zones.

But as the industry enhanced its ability to drill very long extended-reach wells, it was met with challenges other than fluid loss. Operators encountered various pressure-associated challenges while drilling these wells, including wellbore instability and well control problems. Efforts to overcome these challenges gave rise to the development of manage pressure drilling (MPD). MPD is used primarily to drill wells that do not lend themselves to either conventional OBD or UBD methods, such as in areas where flaring is forbidden, or while drilling through high permeability formations (Dave et. al, 2011).

Consistent with Kenneth et. al (2010), UBD, OBD and MPD designate a range of techniques that can be applied and have been developed that fall within these broad ranges illustrated in figure 1.1. Addressing NPT is a major focus for both MPD and UBD. NPT associated with kicks, wellbore breathing, and lost circulation not only will have an immediate impact on rig time and its associated cost, but can also lead to additional costs associated with lost mud, lost circulation materials, additional casing strings, stuck pipe, unplanned sidetracks and in some cases not reaching TD. Any of these can directly affect a project’s financial viability.

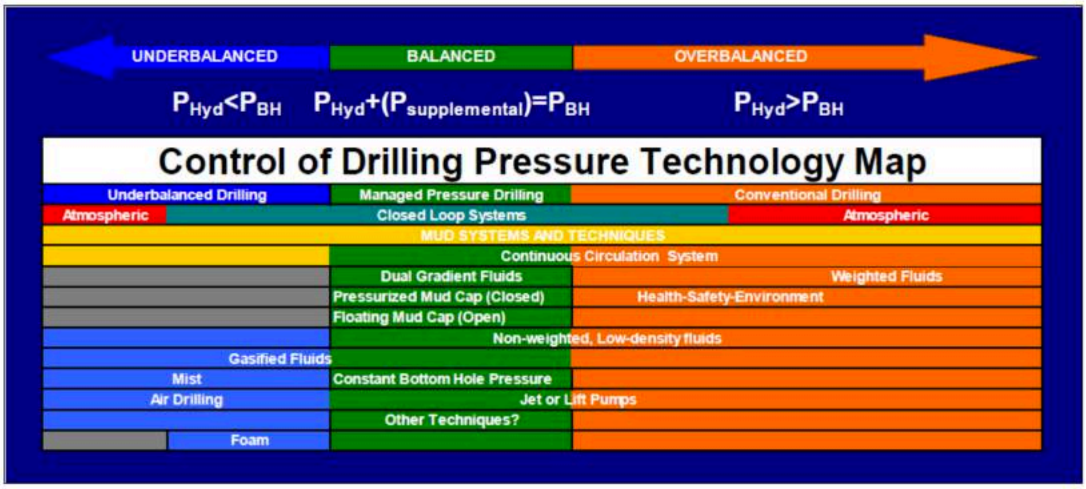

Figure 1.1: UBD, MPD and OBD Classification Chart (Kenneth et. al, 2010)

Drilling wells in complex environments with century-old technology is difficult at best and unsafe at worst. From drilling through narrow pore-pressure-fracture-pressure gradient windows to mitigating kicks and differential sticking, MPD succeeds when conventional techniques are likely to fail.

1.2 Problem Statement

Malaysia oil and gas industry are now focusing towards development of the offshore fields that are being classified as high-pressure high-temperature (HPHT), Ultra-HPHT and deepwater region. This kind of hydrocarbon field is not easy to be drilled with conventional method. There is significant number of drilling incidents involved severe gain and losses scenarios, primarily due to weak coal formations and unsustainable losses across carbonate reservoirs occurred. Problems usually caused by insufficient information to drill deeper because it is an untapped reservoir, no reference well and sometimes the reference are too far, highly doubt this new area will have the same characteristics.

Drilling window is a term that one needs to understand when discussing about drilling operation. Conventionally, pore pressure line and fracture gradient are reasonably distanced to allow for conventional drilling method to be done as shown below in figure 1.2. A single mud weight design will give a different equivalent mud weight (EMW) value during dynamic and static.

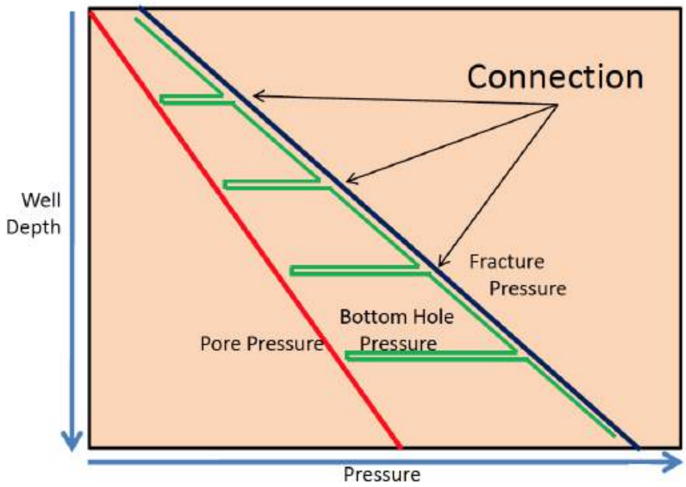

Figure 1.2: Conventional Drilling Window (Syafiq, 2015)

Thus, wellbore need to be sure not to exceed fracture pressure when drilling resume, and not to allow any influx during static (i.e. making up drill pipe connection). However, most of the well now especially those declared ‘undrillable’ doesn’t have this ideal condition anymore. They look more like figure 1.3.

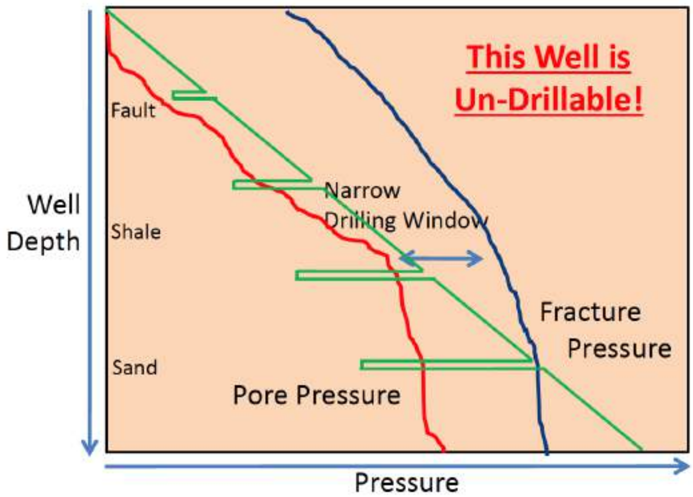

Figure 1.3: Narrow Drilling Window (Syafiq, 2015)

In addition, drillers keep mistaken wellbore breathing/ ballooning phenomena with kick and losses scenario. This could result to questionable mitigation steps and when drilling through soft formation, this phenomenon if not be handled correctly can cause formation breakdown or worst.

Vugular carbonate reservoir on the other hand, will have an unsustainable losses issue. No matter how much lost circulation material being pumped, it will never fully blocked. Drilling in this kind of situation, with continuous losses happen seems to be impossible.

1.3 Objectives

The objectives of this project are as follows:

I. To identify and understand the application of different MPD variations successfully implemented in Malaysia's reservoir.
II. To recognize the differences between these MPD variations and how it can overcome drilling related problems.
III. To study how MPD being used to map pore pressure and fracture gradient in untapped reservoir area accurately and safely.
IV. To analyse technique implemented to drill through vugular carbonate reservoirs, facing continuous losses during drilling operation.

1.4 Scope of Study

The scope of the study is concentrated towards the mechanism involved in MPD system by Schlumberger @balance in order to drill high challenging wells in Malaysia. This includes two MPD variations – PMCD and CBHP.

The scopes of the study:

I. To understand MPD-CBHP operation and MPD-PMCD implementation, how it being selected and used at different wells in Malaysia to overcome drilling related problems.
II. To distinguish techniques used to determine the lower limit (pore pressure) and the upper limit (fracture gradient) while drilling in progress.
III. To detect and differentiate wellbore breathing phenomena as oppose to kick and losses event using MPD system.
IV. To discuss how to mitigate kick and losses event in both MPD variations conditions.
V. To investigate differences between statically overbalanced and hydrostatically underbalanced for MPD-CBHP method.
VI. To assess any other challenges involved or potential risk and weakness that open up new opportunities for improvements ahead.

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